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## 6.4 MAIN CONTROL ROOM HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)

**Learning Objectives:**

1. State the purposes of the Main Control Room HVAC Systems.

2. Describe the major differences between the AP1000 and current operating Westinghouse plants Main Control Room HVAC Systems.

### 6.4.1 Introduction

During normal plant operations the nuclear island nonradioactive ventilation system (VBS) serves the main control room (MCR), technical support center (TSC), Class 1E dc equipment rooms, Class 1E instrumentation and control (I&C) rooms, Class 1E electrical penetration rooms, Class 1E battery rooms, remote shutdown room, reactor coolant pump trip switchgear rooms, adjacent corridors, and the passive containment cooling system (PCS) valve room during normal plant operation.

The main control room emergency habitability system provides main control room habitability in the event of a design-basis accident (DBA).

### 6.4.2 System Description

#### 6.4.2.1 Nuclear Island Nonradioactive Ventilation System

The nuclear island nonradioactive ventilation system provides the following nuclear safety-related design-basis functions:

- Monitors the main control room supply air for radioactive particulate and iodine concentrations, and

- Isolates the HVAC penetrations in the main control room boundary on high-high particulate or iodine concentrations in the main control room supply air, or on extended loss of ac power, to support operation of the main control room emergency habitability system as described in section 6.4.2.2.

Those portions of the nuclear island nonradioactive ventilation system which penetrate the main control room envelope are safety related and designed as seismic Category I to provide isolation of the main control room envelope from the surrounding areas and outside environment in the event of a design basis accident. Other functions of the system are not safety related. HVAC equipment and ductwork whose failure could affect the operability of safety-related systems or components are designed to seismic Category II requirements. The remaining portion of the system is not safety related and nonseismically qualified.

The nuclear island nonradioactive ventilation system is designed to provide a reliable source of heating, ventilation, and cooling to the areas served when ac power is available. The system equipment and component functional capabilities are to minimize the potential for actuation of the main control room emergency habitability system or the potential reliance on passive equipment cooling. This is achieved through the use of redundant equipment and components that are connected to standby onsite ac power sources.

See Figure 6.4-1 for the main control room/technical support HVAC portion of the nuclear island nonradioactive ventilation system.

Refer to AP1000 Design Control Document section 9.4.1 for a detailed description of the nuclear island nonradioactive ventilation system.

### 6.4.2.2 Main Control Room Emergency Habitability System

If ac power is unavailable for more than 10 minutes or if “high-high” particulate or iodine radioactivity is detected in the main control room supply air duct, which would lead to exceeding General Design Criterion 19 operator dose limits, the protection and safety monitoring system automatically isolates the main control room from the nuclear island nonradioactive ventilation system. Operator habitability requirements are then met by the main control room emergency habitability system (VES). The main control room emergency habitability system is capable of providing emergency ventilation and pressurization for the main control room. The main control room emergency habitability system also provides emergency passive heat sinks for the main control room, instrumentation and control rooms, and dc equipment rooms.

The main control room pressure boundary is located at elevation 117’, 6” in the auxiliary building, on the nuclear island. As shown in Figure 6.4-2, the pressure boundary encompasses the main control area, operations work area, operations break room, shift supervisor’s office, kitchen, and toilet facilities. The pressure boundary is represented by the line around the periphery of the boundary in the figure. The stairwell leading down to ground elevation (100’) and the vestibule are specifically excluded from the boundary.

When the main control room pressure boundary is isolated in an accident situation, there is no direct communication with the outside atmosphere, nor is there communication with the normal ventilation system. Leakage from the main control room pressure boundary is the result of an internal pressure of at least 1/8-inch water gauge provided by emergency habitability system operation.

The main control room emergency habitability system air storage tanks are sized to deliver the required air flow to the main control room and to induce sufficient air flow through the passive filtration line to meet the ventilation and pressurization requirements for 72 hours. Normal system makeup is provided by a connection to the breathable quality air compressor in the compressed and instrument air system (CAS). A connection for refilling operation is provided in the CAS.

Flow from the air storage tanks induces a filtration flow of at least 600 cfm. The filtration flow passes through a series of silencers to maintain acceptable main control room noise levels. The passive filtration portion of the system includes a HEPA filter, a charcoal adsorber, and a downstream postfilter. The air intake to the passive filtration ductwork is located near the operations work area. The ductwork is routed behind the main control area through the operations break room to reduce the overall noise level in the main control area. The filtered air supply is then distributed to three supply locations that are sufficiently separated from the air intake to avoid short circuiting of the air flow. Two of the air supplies discharge into the main control area, and the third discharges into the shift supervisor's office. Flow dampers ensure that the filtered air is properly distributed throughout the main control room envelope.

The function of providing passive heat sinks for the main control room, instrumentation and control rooms, and dc equipment rooms is part of the main control room emergency habitability system. The heat sinks for each room are designed to limit the temperature rise inside each room during the 72-hour period following a loss of nuclear island nonradioactive ventilation system operation. The heat sinks consist primarily of the thermal mass of the concrete that makes up the ceilings and walls of these rooms.

To enhance the heat-absorbing capability of the ceilings, a metal form is attached to the interior surface of the concrete at selected locations. Metallic plates are attached perpendicular to the form. These plates extend into the room and act as thermal fins to enhance the heat transfer from the room air to the concrete.

The main control room emergency habitability system piping and instrumentation diagram is shown in Figure 6.4-3.

### 6.4.3 Component Descriptions

Refer AP1000 Design Control Document section 9.4.1.2.2 for detailed descriptions of the nuclear island nonradioactive ventilation system components.

The main control room emergency habitability system compressed air supply contains a set of storage tanks connected to main and alternate air delivery lines. Components common to both lines include a manual isolation valve and a pressure regulating valve. Single active failure protection is provided by the use of redundant, remotely operated isolation valves, which are located within the MCR pressure boundary. In the event of insufficient or excessive flow in the main delivery line, the main delivery line is isolated, and the alternate delivery line is manually actuated. The alternate delivery line contains the same components as the main delivery line with the exception of the remotely operated isolation valves, and thus is capable of supplying compressed air within the MCR pressure boundary at the required air flow rate. The VES piping and penetrations for the MCR envelope are designated as equipment Class C.

#### 6.4.3.1 Emergency Air Storage Tanks

The 32 air storage tanks are constructed of forged, seamless pipe, with no welds, and conform to Section VIII and Appendix 22 of the ASME Code. The design pressure of the air storage tanks is 4000 psi. The storage tanks collectively contain a minimum storage capacity of 327,574 scf.

### 6.4.3.2 Pressure Regulating Valves

Each compressed air supply line contains a pressure regulating valve located downstream of the common header. The pressure at the outlet of the valve is controlled via a two-stage, self-contained pressure control operator. A failure of either stage of the pressure regulating valve does not cause the valve to fail completely open. A failure of the second stage increases the air flow from the emergency air storage tanks. There is adequate margin in the emergency air storage tanks such that, upon failure of the pressure regulating valve in the main delivery line, an operator has time to isolate the line and manually actuate the alternate delivery line.

### 6.4.3.3 Flow Metering Orifices

The flow rate of air delivered to the main control room pressure boundary is limited by an orifice located downstream of the pressure regulating valve. Each orifice is sized to provide the required air flow rate to the main control room pressure boundary.

### 6.4.3.4 Air Delivery Main Isolation Valves

The pressure boundary of the compressed air storage tanks is maintained by normally closed, remotely operated isolation valves in the main supply line. These valves are located within the MCR pressure boundary downstream of the pressure regulating valve and automatically initiate air flow upon receipt of a signal to open.

### 6.4.3.5 Pressure Relief Isolation Valves

To limit the pressure increase within the main control room, isolation valves are provided, one in each of the redundant flowpaths, which open on a time delay after receipt of an emergency habitability system actuation signal. The valves provide a leak tight seal to protect the integrity of the main control room pressure boundary during normal operation, and are normally closed to prevent interference with the operation of the nonradioactive ventilation system.

### 6.4.3.6 Main Air Flowpath Isolation Valve

The main air flowpath contains a normally open, manually operated valve located within the MCR pressure boundary, downstream of the remotely operated air delivery main isolation valves. The valve is provided as a means of isolating and preserving the air storage tanks’ contents in the event of a pressure regulating valve malfunction.

### 6.4.3.7 Air Delivery Alternate Isolation Valve

The alternate air delivery flowpath contains a normally closed, manually operated valve, located within the MCR pressure boundary. The valve is provided as a means of manually activating the alternate air delivery flowpath in the event the main air delivery flowpath is inoperable.

#### 6.4.3.8 Pressure Relief Dampers

Pressure relief dampers are located downstream of the butterfly isolation valves, and are set to open on a differential pressure of at least 1/8-inch water gauge with respect to the surrounding areas. The differential pressure between the control room and the relief damper exhaust location is monitored to ensure that a positive pressure is maintained in the control room with respect to its surroundings.

#### 6.4.3.9 Eductor

An eductor is connected to the discharge of the VES makeup line from the emergency air storage tanks and to the ductwork located inside the MCR envelope that comprises the passive filtration portion of the VES. The eductor directs compressed air from the VES storage tanks through a specially designed nozzle to create a powerful vacuum that draws air from the MCR into the passive air filtration line. The eductor is designed to draw a flow of at least 600 scfm into the passive air filtration elements. This flow rate is based on a VES makeup flow of 65 ± 5 scfm at an approximate pressure of 50 psig at the discharge of the bottled air supply to the eductor. The eductor has no electrical power requirements, contains no moving parts, and requires no maintenance such as adjusting setpoints or lubricating bearings.

#### 6.4.3.10 Filtration Elements

The main control room passive filtration flowpath contains a HEPA filter in series with a charcoal adsorber and a postfilter. They work to remove particulates and iodine from the air to reduce the potential control room dose during VES operation.

#### 6.4.3.11 Silencers

Two silencers are located in the passive air filtration line. One silencer is located downstream of the eductor, and the other silencer is located upstream of the eductor. The silencers are designed to reduce the noise created by the flow in the passive air filtration line.

#### 6.4.3.12 Control Room Access Doors

Two sets of doors, with a vestibule between, are provided at the access to the main control room.

#### 6.4.3.13 Breathing Apparatus

Self-contained portable breathing equipment with air bottles is stored inside the main control room pressure boundary. The amount of stored air is sufficient to provide a 6-hour supply of breathable air for up to 11 main control room occupants. This is backup protection to the permanently installed habitability systems.

### 6.4.4 System Operation

#### 6.4.4.1 Normal Operation

The main control room emergency habitability system is not required to operate during normal conditions. The nuclear island nonradioactive ventilation system maintains the air temperature of a number of rooms within a predetermined temperature range. The rooms with this requirement include the rooms with a main control room emergency habitability system passive heat sink design and their adjacent rooms.

#### 6.4.4.2 Emergency Operation

Operation of the main control room emergency habitability system is automatically initiated by either of the following conditions:

- “High-high” particulate or iodine radioactivity in the main control room supply air duct, or
- Loss of ac power for more than 10 minutes.

Operation can also be initiated by manual actuation.

In response to any of the initiating conditions, the nuclear island nonradioactive ventilation system is isolated from the main control room pressure boundary by automatic closure of the isolation devices located in the nuclear island nonradioactive ventilation system ductwork. At the same time, the main control room emergency habitability system begins to deliver air from the emergency air storage tanks to the main control room by automatically opening the isolation valves located in the supply line. The relief damper isolation valves also open, allowing the pressure relief dampers to function. The discharge through the relief dampers purges the vestibule.

After the main control room emergency habitability system isolation valves are opened, the air supply pressure is regulated by a self-contained regulating valve. This valve maintains a constant downstream pressure regardless of the upstream pressure. A constant air flow rate is maintained by the flow metering orifice downstream of the pressure regulating valve. This flow rate is sufficient to pressurize the main control room to at least 1/8-inch water gauge positive differential pressure with respect to the surroundings and to induce a flow rate of at least 600 cfm through the passive air filtration line. The main control room emergency habitability system air flow rate is also sufficient to maintain the carbon dioxide concentration below 0.5 percent for a maximum of 11 occupants and to maintain the control room air quality within acceptable standards.

The emergency air storage tanks are sized to provide the required air flow to the main control room pressure boundary for 72 hours. After 72 hours, the main control room is cooled by drawing in outside air and circulating it through the room.

The temperature and humidity in the main control room pressure boundary following a loss of the nuclear island nonradioactive ventilation system remain within limits for reliable human performance over a 72-hour period. The initial values of temperature/relative humidity in the MCR are 75°F/60 percent. At 3 hours, when the non-1E battery heat loads are exhausted, the conditions are 87.2°F/41 percent. At 24 hours, when the 24-hour battery heat loads are terminated, the conditions are 84.4°F/45 percent. At 72 hours, the conditions are 85.8°F/ 39 percent.

Sufficient thermal mass is provided in the walls and ceiling of the main control room to absorb the heat generated by the equipment, lights, and occupants. The passive heat sinks limit the air temperature inside the instrumentation and control rooms to 120°F and dc equipment rooms to 120°F. The walls and ceilings that act as the passive heat sinks contain sufficient thermal mass to accommodate the heat sources from equipment, personnel, and lighting for 72 hours. As in the main control room, sufficient thermal mass is provided surrounding these rooms to absorb the heat generated by the equipment. After 72 hours, the instrumentation and control rooms will be cooled by drawing in outside air and circulating it through the room.

In the event of a loss of ac power, the nuclear island nonradioactive ventilation system isolation valves automatically close and the main control room emergency habitability system isolation valves automatically open. These actions protect the main control room occupants from a potential radiation release. In instances in which there is no radiological source term present, the compressed air storage tanks are refilled via a connection to the breathable quality air compressor in the compressed and instrument air system (CAS). The compressed air storage tanks can also be refilled from portable supplies by an installed connection in the CAS.